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Improvements in or relating to telecommunication services.

The present invention relates to a method for reducing access time and improves compression efficiency in broadcast/multicast IP services with unidirectional header compression within a multicast/broadcast multimedia system.

Due to the tremendous success of the Internet, it has become a challenging task to make use of the Internet Protocol (IP) over all kinds of links. However, because of the fact that the headers of the IP protocols are rather large, it is not always a simple task to make this come true for narrow band links, for example cellular links. As an example, consider ordinary speech data transported by the protocols (IP, UDP, RTP) used for Voice-over-IP (VoIP), where the header may represent about 70% of the packet resulting in a very inefficient usage of the link.

The term header compression (HC) comprises the art of minimizing the necessary bandwidth for information carried in headers on a per-hop basis over point-to-point links. The techniques in general have a more than ten-year-old history within the Internet community; several commonly used protocols exist such as RFC 1144, RFC 2507 and RFC 2508. Header compression takes advantage of the fact that some fields in the headers are not changing within a flow, or change with small and/or predictable values. Header compression schemes make use of these characteristics and send static information only initially, while changing fields are sent with their absolute values or as differences from

packet to packet. Completely random information has to be sent without any compression at all.

Header compression is thus an important component to make IP services over wireless, such as voice and video services, economically feasible. Header compression solutions have been developed by the Robust Header Compression (ROHC) Working Group of the IETF to improve the efficiency of such services.

For ROHC compression, the three compressor states are the Initialization and Refresh (IR), First Order (FO), and Second Order (SO) states. The compressor starts in the lowest compression state (IR) and transits gradually to higher compression states.

The context initialization phase (IR state) normally requires the compressor to start using the lowest compression state. Initially, the transmitted packets contain the information necessary to initialize at least the static and maybe the dynamic part of the context.

The compressor must then have enough confidence that the decompressor has the proper context before a transition to a higher compression ratio takes place. This confidence may be achieved in U-mode by sending a number of context initialization packets repeatedly for a large enough interval. The use of a number of packets may achieve confidence in less than one RTT but cannot absolutely guarantee that the decompressor does have the proper context other than optimistically expect to be successful with a high percentage rate.

For example, taken from RFC 3095 on the Unidirectional mode:

"Transition to a higher compression state in Unidirectional mode is carried out according to the optimistic approach

principle. This means that the compressor transits to a higher compression state when it is fairly confident that the decompressor has received enough information to correctly decompress packets sent according to the higher compression state. When the compressor is in the IR state, it will stay there until it assumes that the decompressor has correctly received the static context information. For transition from the FO to the SO state, the compressor should be confident that the decompressor has all parameters needed to decompress according to a fixed pattern."

In addition, to ensure robustness, a compressor operating in U-mode periodically transits back to a lower compression state (e.g. IR state). In this respect, a periodic refresh of the context in U-mode can be viewed as a procedure similar to the context initialization.

In a contribution to 3GPP2, Qualcomm advocates the use of ROHC in unidirectional mode as the preferred header compression algorithm for BCMCS services.
The contribution also proposes the adoption of modifications to the ROHC unidirectional mode of operation for header compression in BCMCS. It is claimed that the existing unidirectional mode of operation in ROHC does not work efficiently enough when used over broadcast links with significant error rates and scarce bandwidth. The contribution proposes that static context information be sent in advance to the decompressor via BCMCS information acquisition, on a separate channel. This contribution proposes to entirely disable the ROHC IR state when operating in U-mode in BCMCS services, and to send the IR parameters out-of-band instead - only once during channel information acquisition. Would a decompressor loose its context, the mobile terminal should initiate a new registration to the

service to trigger a new channel information acquisition exchange.

This proposal however requires significant changes to the state machine logic, as well as an unnecessarily complex interaction between the header compression algorithm and the underlying system. A simpler approach would be preferable. Also, this proposal is limited to one IP multicast/broadcast flow per ROHC instance (ROHC channel). This can pose unnecessary constraints on the processing and memory usage required in the terminal.

More specifically for the ROHC framework, context initialization requires the compressor to start using the lowest compression state, the Initialization and Refresh (IR state). The first transmitted packets are IR packets to initialize at least the static and the dynamic part of the context. The static part may include information such as Context Identifier (CID), compression profile, the IP source and destination addresses, the UDP source and destination ports, SSRC etc. The dynamic part includes information such as RTP sequence number (RTP SN), payload type, timestamps, timestamp stride etc.

The ROHC framework requires that initialization first uses a number of IR packets, and then possibly followed by a number of IR-DYN packets. The size of these packet types, excluding the payload bits, is in the order of tens of octets.

Initialization and periodic refreshes of a header compression context thus require bandwidth for the bits necessary to be exchanged between compressor and decompressor, and this step

is necessary to ensure that higher compression efficiency may be achieved. The confidence from the compressor that the decompressor has achieved proper context implies a certain delay for which the compression efficiency is far from optimal. In some situation, for example real-time VoIP flows over very narrow bandwidth wireless links using 0-byte header compression algorithms, such delay may impact perceived quality until optimal compression efficiency is reached. While the impact for a constant flow is minimal and concealed to the first packets of the flow, it may be more significant for a more bursty and discontinuous flow and should be minimized.

When used over error prone unidirectional links such as wireless broadcast links, a ROHC compressor operating in unidirectional mode (U-mode) faces a very important trade-off between efficiency and reliability. More specifically, when improving spectral efficiency of a header compression operating in a unidirectional mode, both the reliability of the context initialization and the delay to reach the static context state (or full context) at the decompressor (that is the delay from the time when the MS joins the channel and the time the decompressor in the MS can obtain the static context information) must be considered.

When the periodic transition to initialization and refresh (IR) state in the compressor (Timeout_1) is set to a long interval, fewer large IR packets are transmitted, leading to higher bandwidth efficiency. However, since the wireless links have high error rate, there is a fairly high probability for the transmitted packets to be corrupted and cause repeated decompression failures at the decompressor. Once it is forced back to no context (NC) state by such failures, the decompressor may have to wait for a long time until it receives the periodic IR packets from the compressor

necessary to re-establish the context. All packets received during this interval have to be discarded, causing disruption in the service. In addition, the long IR refresh interval will lead to long acquisition time when a MS initially tunes to or switches back to the broadcast channel because the decompressor in the MS cannot be updated immediately.

On the other hand, if the periodic transition to the IR state in the compressor (Timeout_1) is set to happen with a short interval, the decompressor will be able to recover from context loss promptly, achieving higher reliability, and the tuning time for the MS will also be short. However, the large number of IR packets sent will lead to much lower efficiency. Therefore, there is a trade-off in bandwidth efficiency when frequently sending IR packets.

The access time is dependant on the time it takes to successfully obtain the static part of the context and begin decompression of compressed headers. It is thus directly related to the interval between the periodic refreshes as set by the compressor.

For broadcast/multicast services using ROHC in U-mode, it is desirable to ensure a short access time to the IP service (including fast context initialization). This must be done while minimizing the overhead introduced by the header compression algorithm, which purpose is to ensure reliability in the absence of a feedback channel between the decompressor and the compressor.

According to a one aspect of the present invention is provided a method for reducing access time and improve compression efficiency in broadcast/multicast IP services with unidirectional header compression within a multicast/broadcast multimedia system.

- said system generates a state transition signal external to the header compression algorithm to trigger a compressor state transition.
- trigger is derived using one or more broadcast/multicast channel acquisition events initiated by the MS.
- a downward transition is performed by the compressor for reducing the time required for the decompressor to reach static or full context.
- transition to a lower compression state (e.g. IR state) only upon reception of a state transition trigger from a system external to the header compression implementation (i.e. the periodic downward transition at the compressor are not performed).
- the header compressor and/or decompressor are/is implemented according to a header compression schemes in general.

The proposed invention improves the access time for IP multicast/broadcast services when using Robust Header Compression (ROHC) in the unidirectional mode (U-mode) of operation, i.e. it minimizes the delay required for the decompressor in the MS to reach the Full Context (FC) state when joining the channel. In addition, the idea maximizes the spectral efficiency of broadcast and multicast IP services by reducing the overhead incurred from the periodic sending of larger IR packets.

The invention therefore improves the access time by using an explicit state transition trigger from the system to the compressor when an MS accesses a broadcast or a multicast IP service.

This idea is particularly useful for one-to-many applications sent over multicast or broadcast radio channels (such as the so-called Push-to-talk VoIP application, or Push-to-talk over Cellular - PoC). This idea is also very relevant to the BroadCast MultiCast Services (BCMCS) currently being defined in 3GPP2 by the BCMCS ad-hoc group (TSG X) and could be standardized there. The idea may also be potentially useful for 3GPP's MBMS work item and in GSM-Satellite, if ROHC operating in U-Mode is used.

This is particularly applicable to most ROHC profiles, including - but not limited to - the ROHC LLA and the ROHC RTP header compression profiles.

This method also has the advantage of not requiring any change to any of the ROHC standards.
Finally, as mentioned earlier, it can be expected that the idea presented in this document could receive support within 3GPP2, and possibly 3GPP as well.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates the compressor state machine.

Figure 2 illustrates the U-mode state machine.

Figure 3 illustrates additional logic when CR state is possible.

Figure 4 illustrates one embodiment of the invention based on BCMCS architecture.

Figure 5 illustrates the resulting state machine for U-mode when invention used.

A glossary of the abbreviations used in this patent specification is set out below to facilitate an understanding of the present invention.

ROHC	Robust Header Compression
U-mode	unidirectional mode
FC	Full Context
RAN	radio access network
MS	mobile station
CID	Context Identifier PS
MBMS	Multicast/Broadcast Multimedia System
PoC	Instant-Talk-over-Cellular
PDSN	Packet Data Serving Node
BCMCS	Broadcast-Multicast Service
IR	Initialization and Refresh state
FO	First Order state
SO	Second Order state
VoIP	Voice-over-IP

ROHC, as defined in RFC 3095, is an extensible framework for which profiles for compression of various protocols may be defined. For real-time multimedia services (e.g. voice, video), the application data is transported end-to-end within

an IP/UDP/RTP stream. Header compression of IP/UDP/RTP is defined by the ROHC profile 0x0001 (ROHC RTP) and is applicable for Voice-over-IP (VoIP) services among others. The ROHC RTP header compression scheme has been designed to efficiently compress the IP/UDP/RTP headers over an arbitrary link layer.

A number of other ROHC profiles have also been defined for compression of:

- IP/UDP/RTP headers (RFC 3242 and RFC 3408);
- IP only headers;
- IP/TCP headers;
- IP/UDP-Lite/RTP headers.

Except for negotiation, ROHC profiles only requires framing and error detection to be provided by the link layer, while all other functionality is handled by the ROHC scheme itself.

Modes of operation

The ROHC profiles defined in RFC 3095, RFC 3242, RFC 3408, all support three different modes of operation. In short, for a specific context, the mode controls the actions and the logic to perform as well as the packet types to use during different states of the header compression operation. Packet types and formats that are allowed may vary from one mode to the other. The Unidirectional mode (U-mode) is used at the beginning of any ROHC compression before any transition to other modes may occur. The Bidirectional Optimistic mode (O-mode) aims to maximize the compression efficiency and sparse

usage of the feedback channel. The Bidirectional Reliable mode (R-mode) aims to maximize robustness against loss propagation and context damage propagation.

When in U-mode, packets are sent from compressor to decompressor only; this mode is thus usable over links where a return path from decompressor to compressor is either not desired or not available, and periodical refreshes are used in this mode. The U-mode is particularly applicable to broadcast or multicast channels. The O-mode is similar to the U-mode with the difference that a feedback channel is used to send error recovery requests and (optionally) acknowledgements of significant context updates from the decompressor to compressor. Note that for most ROHC profiles, the U-mode and the O-mode are often indistinctly referred to using the term U/O-mode, due their rather similar characteristics - such as an identical set of packets formats for both modes. The R-mode differs significantly from the two other modes, mainly by making a more extensive usage of the feedback channel and a stricter logic for performing context updates. The R-mode also uses a few different packet types only understood and useful in this mode.

Each mode of operation has different properties in terms of compression efficiency, robustness and processing complexity. Mode transitions may only be initiated by the decompressor, and ROHC does not specify how and when each mode should be used (other than that ROHC compression must always start in U-mode), therefore the logic for mode transitions is an implementation decision and may be based on measurements of the link characteristics, link conditions, implementation optimizations for a specific mode or may be based on other algorithms. In particular, for Broadcast/Multicast type of

services, header compression operates in the unidirectional mode (U-Mode) only, as normally for such services a feedback channel from decompressor to compressor is not available or desired.

Header compression state machines and context synchronization

One can usually realize a header compression scheme (such as a ROHC Profile) as a state machine and the challenging task is to keep the compressor and decompressor states, called contexts, consistent with each other, while keeping the header overhead as low as possible. There is one state machine for the compressor, and one state machine for the decompressor. The compressor state machine directly impacts the level of compression efficiency, as it is an important part of the logic controlling the choice of compressed packet type to be sent; the purpose of the decompressor state machine is mainly to provide the logic for feedback (if applicable) and to identify the packet types for which decompression may be attempted.

A compression context contains and maintains relevant information about past packets, and this information is used to compress and decompress subsequent packets. Taken from [ROHC]:

"The context of the compressor is the state it uses to compress a header. The context of the decompressor is the state it uses to decompress a header. Either of these or the two in combination are usually referred to as "context", when it is clear which is intended. The context contains relevant information from previous headers in the packet stream, such as static fields and possible reference values for

compression and decompression. Moreover, additional information describing the packet stream is also part of the context, for example information about how the IP Identifier field changes and the typical inter-packet increase in sequence numbers or timestamps."

Compressor state machine in unidirectional mode of operation

For the ROHC profiles defined, figure 1 shows the compressor state machine. From RFC 3095, section 4.3.1:

"For ROHC compression, the three compressor states are the Initialization and Refresh (IR), First Order (FO), and Second Order (SO) states. The compressor starts in the lowest compression state (IR) and transits gradually to higher compression states. The compressor will always operate in the highest possible compression state, under the constraint that the compressor is sufficiently confident that the decompressor has the information necessary to decompress a header compressed according to that state."

In particular, decisions about transitions between the various compression states while operating in U-Mode are normally taken by the compressor on the basis of variations in packet headers and periodic timeouts. RFC 3095 defines the Initialization and Refresh (IR) State, in section 4.3.1, as follow:

The purpose of the IR state is to initialize the static parts of the context at the decompressor or to recover after failure. <u>In this state, the compressor sends complete header information.</u> This includes all static and nonstatic fields in uncompressed form plus some additional information. The compressor stays in the IR state until it is fairly confident

that the decompressor has received the static information correctly.

The IR state is thus the state were the compression level is the lowest. Furthermore, RFC 3095 defines the U-Mode state machine, in section 5.3.1, as shown in figure 2:

In addition, the context replication (CR) mechanism for ROHC profiles introduce an additional state, the CR state. It is noted that as of this writing, only the ROHC-TCP profile specifies support for context replication but other profiles may also support it provide their corresponding standard is updated. This state may also be used by a profile operating in U-Mode, and the additional logic is shown in figure 3. In U-Mode, downward transitions are performed according to the same logic as shown in figure.

Broadcast and Multicast Services (BCMCS)

Broadcast and multicast services differ from unicast services in that they do not specifically target a single receiver, but are rather forms of transmission where multiple recipients will receive the service. Where unicast transmit to an address (either network or link-layer address) corresponding to one and only one receiver, broadcast and multicast uses addresses shared by a number, or a group, of receivers. A broadcast is generally a transmission that can be received by anyone who can tune to the channel, while multicast is a transmission between a sender and multiple specific receivers on a network.

BCMCS requirements

The Third Generation Partnership Project 2 (3GPP2) has placed the following requirement in section 7.1, for BCMCS transmission of data:

> IP Headers: It shall be possible to use IP Header Compression.

Of particular interest for such services is the robustness characteristics of the header compression scheme over channel with relatively high bit error rates, with no or limited link retransmissions and with no or limited feedback capability. With respect to this, ROHC has a clear advantage when compared to other existing header compression schemes such as CRTP and eCRTP.

In addition, section 8.1.6 states the following requirement:

The service to a user shall be activated upon request for a BCMCS program for which the user is authorized.

The above implies that simply tuning to a channel will not be sufficient for a device to receive the broadcast or multicast service; an activation step of some form over the air interface is required, including authorization and possibly some bearer setup procedures.

This requirement can open some opportunities to optimize the header compression algorithm for broadcast/multicast services.

3GPP2 BCMCS Framework

This work provides an architectural overview and a framework description of the Broadcast-Multicast Service (BCMCS) for

the cdma2000®[1] networks. The main purpose of the BCMCS is to allow optimization of the use of the cdma2000® radio interface for delivery of BCMCS content stream(s) to one or more terminals in one or more regions of an operator's network.

Said Framework defines the use of a controller. Section 4.2 page 12, specifically includes in the architecture an interface between this controller and the Packet Data Serving Node (PDSN, similar in functionality to 3GPP's SGSN). This interface provides BCMCS session related information such as Flow Treatment (e.g., header compression, or header removal), the mapping between the identifiers used to distinguish the BCMCS flows (BCMCS_FLOW_ID) and Multicast IP address and port number from the BCMCS Controller to the PDSN. This interface also exchanges the BCMCS authorization information for bearer path setup of BCMCS.

The presence of the interface BCMCS controller - PDSN in the BCMCS architecture can open some opportunities to optimize the header compression algorithm for broadcast/multicast services, by providing means for the BCMCS controller to signal the PDSN that a new user is accessing the BCMCS service.

This same document, Section 4.2 page 13, also includes an interface between the BCMCS controller and the mobile terminal. The purpose of this interface is to provide the BCMCS client application in the MS with access to information about available BCMCS sessions: including Content Provider Name, Content Name, BCMCS_FLOW_ID(s), start time of the BCMCS session, duration of the BCMCS session, flow treatment (e.g.,

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header compression, or header removal), and session description (e.g., codec type), and the transport and application protocols etc.

The presence of the interface BCMCS controller - Mobile Station in the BCMCS architecture can open some opportunities to optimize the header compression algorithm for broadcast/multicast services, by providing means for the terminal to make reliable access to the service. BCMCS Bearer Path Establishment.

The BCMCS bearer paths (connections between BSC - PCF and PCF - PDSN) are setup by the network upon registration by the user using IOS signaling messages (likely within a block of bits - BLOBs). BCMCS services use its own connection, independent of other existing non-BCMCS service instance to the MS.

Said Framework also states that upon the bearer path being established, if header compression is enabled by the PDSN, the PDSN will periodically send the header context on the same bearer path.

Applications: Push-to-talk

Currently Ericsson is developing an open standard for a service called Instant-Talk-over-Cellular (PoC) that will be applied in handsets for GSM, EDGE, UMTS and CDMA systems. Instant-Talk-over-Cellular (PoC) is a "walkie-talkie" in a cellular telecommunication system. PoC enabled handsets will most likely be equipped with a PoC-button (hardware or software). When this button is pressed the handset connects you directly to a friend, a family member, or even a whole

group of people of your choice, one-to-one or one-to many. Like a "walkie-talkie" the PoC service is half-duplex, although full duplex may be available at a later stage. It is important to have low setup delay in order to allow for the user to start speak immediately after pressing the button. It is also important that the PoC service is supported in an efficient manner in the radio network since it is expected to be cheaper than circuit switched voice and since it is likely to become a mass-market service with high penetration.

A typical usage of PoC is that a group of persons (e.g. youths, or professionals like workers at a building site) use the PoC terminals to keep the group updated on what is on-going. It is also likely that the group participants are geographically co-located. Current solutions use one dedicated radio channel (and core network) resource per group participant also in this scenario, which obviously is costly in terms of both radio and core network resources. It is thus foreseeable that such service may be used over a multicast (BCMCS) service.

Applications: Satellite communications

The idea presented in this document may also be useful for satellite communications in systems such as the one described in GSM-AXIP.

Problematic

The problem addressed is that when operating in U-Mode, efficiency is limited from the tradeoff between the frequency of context updates (e.g. downward transitions) for the purpose of maintaining synchronized contexts at both ends of

the link, and the time for a decompressor having no suitable context to resynchronize with the compressor context - such as after a burst of errors or when acquiring the broadcast/multicast channel.

The following describes a potential embodiment of the solution, addressing the compressor state transition and based on, but not limited to, the above description of a broadcast/multicast service as well as the compressor behavior as described in RFC 3095.

As outlined above, it is desired to find a solution that will further optimize the header compression efficiency in system for which delay towards optimal compression operation must be minimized and for which bandwidth is very limited.

The *access delay improvement* may be achieved by introducing/defining a system-specific (external to the header compression logic) IR state transition signal towards the compressor. This signal is generated by the system upon an access or service registration attempt from a mobile station (MS) to the radio access network (RAN) when requesting access to a broadcast/multicast channel or service. The compressor receives this signal and this trigger the context initialization and refresh (i.e. transition to IR State) procedure. A number of IR packets are thus sent upon reception of this trigger (optimistic approach) - preferably over the BCMCS bearer to all receivers, or even using a separate bearer depending on how reliability is achieved.

The *reliability of the context initialization* phase may be achieved in two different ways:

1) By requiring that the decompressor re-initiates the access to the broadcast/multicast IP service (in whole or in parts) upon failure of the context initialization procedure at the decompressor (i.e. no IR packets could initialize the new context).

This makes it possible for the compressor to set the timeout value (U-mode) for the transition back to the IR state (Timeout_1) to a rather large (or even infinite) value, based on:

a) the understanding that IR packets need only be sent upon a state transition trigger generated by the underlying system to the compressor upon the MS making an access to the broadcast/multicast service;

b) the agreement that the MS will re-initiate the access upon static context damage or initialization failure.

2) By requiring that packets initializing the context (at least the static part) be transmitted reliably, possibly on a separate bearer.

The above are alternatives to the normal behaviour of having an MS waiting for the next periodic refreshes of the static part of the context over the multicast/broadcast channel to acquire the static context and transit to a higher compression state.

Figure 4 shows a possible embodiment of the solution based on the above description of the BCMCS architecture. The following comments on the figure are noted:

- the header compressor (ROHC HC) may also be located in a different node (e.g. in the RAN);
- the PDSN equivalent in the 3GPP architecture is the SGSN;
- the AAA is optional, but normally present;
- the BCMCS controller may be co-located with the PDSN (or SGSN).

This invention allows the compressor to perform context initialization more efficiently, and removes the absolute need for periodic updates (Timeout_1 can be set to infinite) in multicast/broadcast services. This is made possible from the fact that other procedures - such as BCMCS information acquisition and/or registration to the service - may occur prior to the first packet within a session, and is particularly advantageous in multicast/broadcast systems where service and/or channel acquisition parameters are not statistically provided.

The net result of this procedure is that fewer bits are transmitted and delay towards accessing the service is minimized.

An example of the resulting state machine for U-mode is in figure 5:

Finally, it should be noted that even if the generic terms *header compression*, *header compressor* and *header decompressor* are used to show that the applicability of this idea is not limited to any specific header compression scheme.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

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Claims

1. A method for reducing access time and improves compression efficiency in broadcast/multicast IP services with unidirectional header compression within a multicast/broadcast multimedia system *characterized in* that said system generates a state transition signal external to the header compression algorithm to trigger a compressor state transition.

2. A method according to claim 1 *characterized in* that the trigger is derived using one or more broadcast/multicast channel acquisition events initiated by the MS.

3. A method according to claim 1 *characterized in* that a downward transition is performed by the compressor for reducing the time required for the decompressor to reach static or full context.

4. A method according to claim 1 *characterized in* that transition to a lower compression state (e.g. IR state) only upon reception of a state transition trigger from a system external to the header compression implementation (i.e. the periodic downward transition at the compressor are not performed).

5. A method according to claim 1 *characterized in* that the header compressor and/or decompressor are/is implemented according to a header compression schemes in general.

Abstract

A method for reducing access time and improve compression efficiency in broadcast/multicast IP services with unidirectional header compression within a multicast/broadcast multimedia system. Said system generates a state transition signal external to the header compression algorithm to trigger a compressor state transition.

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Fig 1

```
+-----------+             +-----------+             +-----------+
| IR State  | <---------> | FO State  | <---------> | SO State  |
+-----------+             +-----------+             +-----------+
```

Fig 2

```
                       Optimistic approach
  +------>------>------>------>------>------>------>------>------+
  |                                                               |
  |      Optimistic approach          Optimistic approach         |
  |      +------>------>------+      +------>------>------+       |
  |      |                    |      |                    |       |
  |      |                    v      |                    v       v
+-----------+           +-----------+            +-----------+
| IR State  |           | FO State  |            | SO State  |
+-----------+           +-----------+            +-----------+
  ^      ^                    |      ^                    |       |
  |      |     Timeout_1      |      | Timeout_2 / Update |       |
  |      +------<------<------+      +------<------<------+       |
  |                                                               |
  |                             Timeout                           |
  +------<------<------<------<------<------<------<------<------+
```

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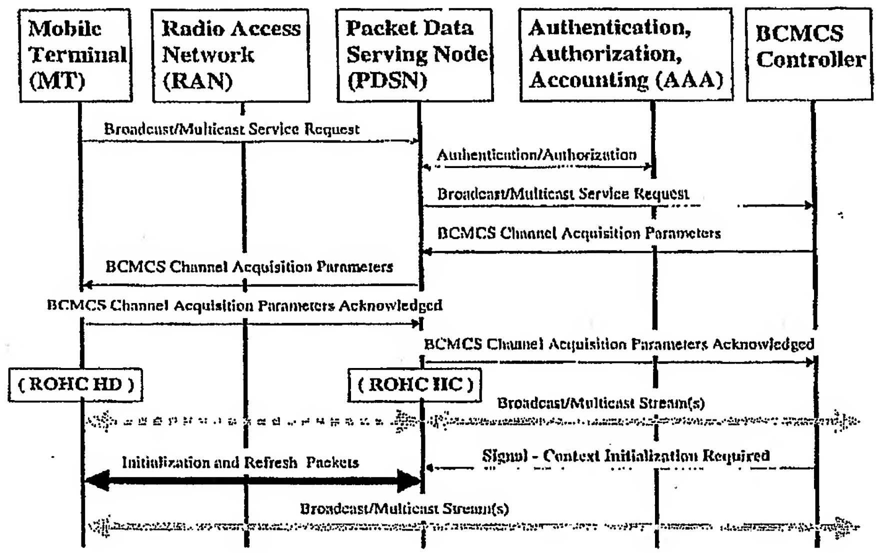
Fig 3

```
          BCID selection              Optimistic approach
        +------>------>-------+   +------>------>------>------+
        |                     |   |                           |
        |                     v   |                           v
  +----------+          +----------+              +--------------+
  |    IR    |          |    CR    |              |    Higher    |
  |   state  |          |   state  |              |  order state |
  +----------+          +----------+              +--------------+
```

Fig 4


Mobile Terminal (MT)
Radio Access Network (RAN)
Packet Data Serving Node (PDSN)
Authentication, Authorization, Accounting (AAA)
BCMCS Controller
Broadcast/Multicast Service Request
Authentication/Authorization
Broadcast/Multicast Service Request
BCMCS Channel Acquisition Parameters
BCMCS Channel Acquisition Parameters
BCMCS Channel Acquisition Parameters Acknowledged
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(ROHC HD)
(ROHC HC)
Broadcast/Multicast Stream(s)
Initialization and Refresh Packets
Signal - Context Initialization Required
Broadcast/Multicast Stream(s)

Fig 5

```
                        Optimistic approach
  +------->------->------->------->------->------->------->------->------+
  |                                                                      |
  |       Optimistic approach             Optimistic approach            |
  |      +------>------>-------+         +------>------>-------+         |
  |      |                     |         |                     |         |
  |      |                     v         |                     v         v
+-----------+             +-----------+                    +-----------+
| IR State  |             | FO State  |                    | SO State  |
+-----------+             +-----------+                    +-----------+
      ^                          ^                               |
      |                          | Timeout_2 / Update            |
      |                          +------<------<-------<---------+
      |
State Transition Trigger
(External signal from underlying system)
```